

WHAT IS CLAIMED IS:

1. An image reading imaging optical system for imaging image information on a line sensor and reading the image information, characterized by an 5 imaging optical element including a plurality of off-axial reflecting surfaces differing in the direction of incidence and the direction of emergence of a reference axis ray from one another and having curvatures.
- 10 2. An image reading imaging optical system according to Claim 1, characterized in that said imaging optical element has the function of changing the direction of emergence to a direction substantially perpendicular or opposite to the direction of incidence of the reference axis ray.
- 15 3. An image reading imaging optical system according to Claim 1 or 2, characterized in that said imaging optical element comprises a plurality of off-axial reflecting surfaces including at least one set 20 of reflecting surfaces intersecting with each other, and has a stop between the off-axial reflecting surfaces intersecting with each other.
- 25 4. An image reading apparatus having an original supporting table on which an original is

placed, an imaging optical element and a line sensor,  
and for causing image information on the surface of  
the original to be imaged on the line sensor by the  
imaging optical element, and reading the image  
5 information by said line sensor, characterized in  
that said imaging optical element has a plurality of  
off-axial reflecting surfaces differing in the  
direction of incidence and the direction of emergence  
of a reference axis ray from one another and having  
10 curvatures.

5. An image reading apparatus according to  
Claim 4, characterized in that the bending direction  
of the reference axis ray on each off-axial  
15 reflecting surface of said imaging optical element is  
in a cross section perpendicular to the line  
direction of said line sensor.

6. An image reading apparatus according to  
20 Claim 5, characterized in that the direction of the  
reference axis ray emerging from said imaging optical  
element differs from the direction of the reference  
axis ray incident on said imaging optical element.

25 7. An image reading apparatus according to  
Claim 6, characterized in that the direction of the  
reference axis ray emerging from said imaging optical

element is substantially orthogonal to the direction of the reference axis ray incident on said imaging optical element.

5               8. An image reading apparatus according to  
Claim 5, characterized in that the direction of the  
reference axis ray emerging from said imaging optical  
element is substantially the same direction as the  
direction of the reference axis ray incident on said  
10 imaging optical element.

9. An image reading apparatus according to  
Claim 6, characterized in that the direction of the  
reference axis ray incident on said imaging optical  
element and the direction of the reference axis ray  
emerging from said imaging optical element are  
substantially opposite directions.

10. An image reading apparatus according to  
20 Claim 4, characterized in that said image information  
is not intermediately imaged in said imaging optical  
element, but is directly formed on the line sensor.

11. An image reading apparatus according to  
25 Claim 10, characterized in that said imaging optical  
element has a stop near substantially the center of  
the optical path between the light incidence surface

and the light exit surface thereof.

12. An image reading apparatus according to  
Claim 11, characterized in that said stop is formed  
5 by the effective surface of an off-axial reflecting  
surface located near substantially the center of the  
optical path between the light incidence surface and  
the light exit surface of said imaging optical  
element.

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13. An image reading apparatus according to  
Claim 4, characterized in that an internal medium  
constituting said imaging optical element is air.

15

14. An image reading apparatus according to  
Claim 4, characterized in that an internal medium  
constituting said imaging optical element is  
optically transparent glass or plastic.

20

15. An image reading apparatus according to  
Claim 5, characterized in that when the off-axial  
reflecting surface for counter-clockwisely deflecting  
the reference axis ray is defined as a plus  
deflecting surface, and the off-axial reflecting  
25 surface for clockwisely deflecting the reference axis  
ray is defined as a minus deflecting surface, said  
imaging optical element has at least one set of

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constructions in which the plus deflecting surface is continuous or at least one set of constructions in which the minus deflecting surface is continuous.

5        16. An image reading apparatus according to  
Claim 5, characterized in that when the off-axial  
reflecting surface for counter-clockwisely deflecting  
the reference axis ray is defined as a plus  
deflecting surface, and the off-axial reflecting  
10      surface for clockwisely deflecting the reference axis  
ray is defined as a minus deflecting surface, said  
imaging optical element has at least one set of  
constructions in which the plus deflecting surface is  
continuous and at least one set of constructions in  
15      which the minus deflecting surface is continuous.

17. An image reading apparatus according to  
Claim 5, characterized in that said imaging optical  
element is comprised of six off-axial reflecting  
20      surfaces, and when the off-axial reflecting surface  
for counter-clockwisely deflecting the reference axis  
ray is defined as a plus deflecting surface, and the  
off-axial reflecting surface for clockwisely  
deflecting the reference axis ray is defined as a  
25      minus deflecting surface, said imaging optical  
element has the same number of plus deflecting  
surfaces and minus deflecting surfaces, and the

off-axial reflecting surface most adjacent to the  
exit side is disposed on the original side on the  
incidence reference axis relative to the off-axial  
reflecting surface most adjacent to the incidence  
5 side.

18. An image reading apparatus according to  
Claim 17, characterized in that said plus deflecting  
surfaces and said minus deflecting surfaces are  
10 disposed so as to be opposite deflecting surfaces  
relative to a stop.

19. An image reading apparatus according to  
Claim 17, characterized in that the off-axial  
15 reflecting surface of said imaging optical element  
which is most adjacent to the incidence side is  
designed to have the converging action.

20. An image reading apparatus according to  
Claim 17, characterized in that at least one surface  
20 of said imaging optical element has a characteristic  
of cutting infrared light.

21. An image reading apparatus according to  
Claim 17, characterized in that said imaging optical  
25 element is disposed in a housing along the surface of  
the original in parallel to a reflecting mirror.

22. An image reading apparatus according to  
Claim 4, characterized in that when the effective  
beam width in a direction perpendicular to the line  
direction of the line sensor on the exit surface of  
5 said imaging optical element is defined as  $\Phi_s$ , and  
the effective beam width in the line direction of the  
line sensor is defined as  $\Phi_m$ , the condition that

$$\Phi_s < \Phi_m$$

is satisfied.

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23. An image reading apparatus having an  
original supporting table on which an original is  
placed, an imaging optical element and a line sensor,  
and for causing image information on the surface of  
15 the original to be imaged on the line sensor by the  
imaging optical element, and reading the image  
information by said line sensor, characterized by a  
reflecting mirror and an imaging optical element for  
reflecting a reference axis ray a plurality of times,  
20 and in that said imaging optical element has the  
function of changing the direction of emergence to a  
direction substantially perpendicular or opposite to  
the direction of incidence of the reference axis ray.

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24. An image reading apparatus according to  
Claim 23, characterized in that said imaging optical  
element has a plurality of off-axial reflecting

surfaces differing in the direction of incidence and the direction of emergence of the reference axis ray from one another and having curvatures.

5        25. An image reading apparatus according to  
Claim 24, characterized in that the bending direction  
of the reference axis ray on each off-axial  
reflecting surface is in a cross section  
perpendicular to the line direction of said line  
10 sensor.

26. An image reading apparatus according to  
claim 24, characterized by at least two reflecting  
mirrors.

15        27. An image reading apparatus according to  
Claim 24, characterized in that said imaging optical  
element is disposed on the side opposite to the  
surface of said original with respect to said  
20 reflecting mirror.

28. An image reading apparatus according to  
Claim 24, characterized in that said imaging optical  
element is disposed in a housing along the surface of  
25 said original in parallel to said reflecting mirror.

29. An image reading apparatus having an

original supporting table on which an original is placed, an imaging optical element and a line sensor, and for causing image information on the surface of the original to be imaged on the line sensor, and  
5 reading the image information by said line sensor, characterized in that said imaging optical element includes a plurality of off-axial reflecting surfaces including at least one set of reflecting surfaces intersecting with each other, and has a stop between  
10 the off-axial reflecting surfaces intersecting with each other.

30. An image reading apparatus according to Claim 29, characterized in that the bending direction  
15 of a reference axis ray on each off-axial reflecting surface of said imaging optical element is in a cross section perpendicular to the line direction of said line sensor.

20 31. An image reading apparatus according to Claim 30, characterized in that the stop in said imaging optical element is disposed near substantially the center of the optical path between the light incidence surface and the light exit  
25 surface of the imaging optical element.

32. An image reading apparatus according to

Claim 30, characterized in that said stop differs in  
the aperture width thereof in a cross section  
perpendicular to the line direction of the sensor  
line and the aperture width in a direction parallel  
5 to the line direction.

33. An image reading apparatus according to  
Claim 32, characterized in that said stop is  
constructed integrally with the off-axial reflecting  
10 surfaces proximate thereto.

34. An image reading apparatus according to any  
one of Claims 4 to 33, characterized in that said  
image information is a color image.